

TOPIC 13 – PERIODICITY

13.1 – TRENDS ACROSS PERIOD 3

IB Chemistry
T03D03



13.1 – Trends Across Period 3

2 hrs

- 13.1.1 Explain the physical states (under standard conditions) and electrical conductivity (in the molten state) of the chlorides and oxides of the elements in period 3 in terms of their bonding and structure. (3)
- 13.1.2 Describe the reactions of chlorine and the chlorides referred to in 13.1.1 with water. (2)



Physical States of Chlorides and Oxides

13.1.1 Explain the physical states (under standard conditions) and electrical conductivity (in the molten state) of the chlorides and oxides of the elements in period 3 in terms of their bonding and structure. (3)

■ Reactions of Period-3 elements with O₂:

Name	Description of Element + O ₂	Equation for Reaction
Na	Burns an orange flame → white solid	$4\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{Na}_2\text{O(s)}$
Mg	Burns bright white → white solid	$2\text{Mg(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{MgO(s)}$
Al	Burns on heating in O ₂ → white solid	$4\text{Al(s)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{Al}_2\text{O}_3\text{(s)}$
Si	Burns on heating in O ₂ → white solid	$\text{Si(s)} + \text{O}_2\text{(g)} \rightarrow \text{SiO}_2\text{(s)}$
P	White P spontaneously burns → white (s)	Limited air: $\text{P}_4 + 3\text{O}_2 \rightarrow \text{P}_4\text{O}_6$ Excess air: $\text{P}_4 + 5\text{O}_2 \rightarrow \text{P}_4\text{O}_{10}$
S	Burns with blue flame → colorless gas	$\text{S(s)} + \text{O}_2\text{(g)} \rightarrow \text{SO}_2\text{(g)}$
Cl	Does not directly react with oxygen	

Acidic Properties of Oxides

- As discussed with SL material, the oxides across period 3 go from basic to acidic.
- You should be able to
 - Identify the trend
 - Write the reaction for formation of each oxide
 - Write the equation for a reaction with water
- We did not discuss **chlorine** before:
 - $\text{Cl}_2\text{O}(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons 2\text{HClO}(\text{aq}) \rightleftharpoons 2\text{H}^+(\text{aq}) + 2\text{ClO}^-(\text{aq})$
 - But the compound Cl_2O is very unstable:
 - $2\text{Cl}_2\text{O}(\text{g}) + 2\text{Cl}_2(\text{g}) + \text{O}_2(\text{g})$



Trend of Oxides

Physical States:

- Ionic Oxides: Giant covalent Structure: Solids at STP
- Covalent Oxides: Simple covalent, liquids or solids with low M.P.'s

Formula:

Formula	Na ₂ O	MgO	Al ₂ O ₃	SiO ₂	P ₄ O ₁₀	SO ₃	Cl ₂ O ₇
El : O	0.5	1.0	1.5	2.0	2.5	3.0	3.5

Conductivity:

- Ionic's: conductive when molten (liquid)
- Covalent's: non-conductive, although some products of reactions in H₂O produce ions



13.1

Reactions of Cl_2 and Chlorides in H_2O

13.1.2 Describe the reactions of chlorine and the chlorides referred to in 13.1.1 with water. (2)

■ Reactions of chlorine across period 3

Name	Description of Reaction	Equation for Reaction
Na	Hot Na \rightarrow white solid	$2\text{Na(s)} + \text{Cl}_2\text{(g)} \rightarrow 2\text{NaCl(s)}$
Mg	Hot Mg \rightarrow white solid	$\text{Mg(s)} + \text{Cl}_2\text{(g)} \rightarrow \text{MgCl}_2\text{(s)}$
Al	Reacts on heating \rightarrow pale yellow solid	$2\text{Al(s)} + 3\text{Cl}_2\text{(g)} \rightarrow 2\text{AlCl}_3\text{(s)}$
Si	Reacts on heating \rightarrow colorless liquid	$\text{Si(s)} + 2\text{Cl}_2\text{(g)} \rightarrow \text{SiCl}_4\text{(l)}$
P	White P reacts with limited $\text{Cl}_2 \rightarrow$ colorless liquid	Limited Cl_2 : $2\text{P(s)} + 3\text{Cl}_2\text{(g)} \rightarrow 2\text{PCl}_3\text{(l)}$ Excess Cl_2 : $2\text{P(s)} + 5\text{Cl}_2\text{(g)} \rightarrow 2\text{PCl}_5\text{(s)}$

Na and Mg Chlorides in Water

■ Sodium Chloride:

- A colorless solid that dissolves in water to form a neutral solution
- $\text{NaCl(s)} + (\text{aq}) \rightarrow \text{NaCl(aq)}$

■ Magnesium Chloride:

- A colorless solid that dissolves in water to form a slightly acid solution (topic 08)
- $\text{MgCl}_2(\text{s}) + (\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq})$



Al Chloride in water

- Aluminum Chloride:
 - Volatile white substance that sublimates (s→g) at a low temperature
 - $\text{AlCl}_3(\text{s}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow \text{Al}(\text{OH})_3(\text{aq}) + 3\text{HCl}(\text{aq})$
- In excess water, forms a complex ion:
 - $\text{AlCl}_3(\text{s}) + (\text{aq}) \rightarrow [\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq}) + 3\text{Cl}^-(\text{aq})$
- The complex ion is acidic, producing H^+ ions
 - $[\text{Al}(\text{H}_2\text{O})_6]^{3+}(\text{aq}) \rightarrow [\text{Al}(\text{H}_2\text{O})_5\text{OH}]^{2+}(\text{aq}) + \text{H}^+(\text{aq})$
- We will revisit the acid/base properties of complex ions (which are lewis acid/base compounds) in topic 08.



Si and P Chlorides in Water

■ Silicon Tetrachloride:

- Colorless, volatile covalent liquid
- $\text{SiCl}_4(\text{l}) + 2\text{H}_2\text{O}(\text{l}) \rightarrow \text{SiO}_2(\text{s}) + 4\text{HCl}(\text{g})$

■ Phosphorus trichloride:

- Colorless, covalent liquid, fumes in humid air
- $\text{PCl}_3(\text{l}) + 3\text{H}_2\text{O}(\text{l}) \rightarrow \text{H}_3\text{PO}_4(\text{aq}) + 3\text{HCl}(\text{aq})$

■ Phosphorus pentachloride:

- Pale yellow covalent solid, sublimates at high temps
- $\text{PCl}_5(\text{s}) \rightarrow \text{PCl}_3(\text{l}) + \text{Cl}_2(\text{g})$ (decomposition)



S and Cl Chloride in water

- Sulfur tetrachloride:
 - SCl_4 is the highest member
 - SCl_6 is predicted as unstable due to the size of chlorine atoms
- Chlorine (chlorine chloride – odd right?)
 - Poisonous pale green gas with pungent odor
 - Moderately soluble in water
 - $\text{Cl}_2(\text{g}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{HCl}(\text{aq}) + \text{HClO}(\text{aq})$



Summary of chloride properties:

Element	Na	Mg	Al	Si	P	Cl
Formula	NaCl	MgCl ₂	AlCl ₃	SiCl ₄	PCl ₃ PCl ₅	Cl ₂
State	Solid	Solid	Solid	Liquid	(l) (s)	Gas
Ox. #	+1	+2	+3	+4	+3 +5	0
Structure	Ionic	Ionic	Covalent	Covalent	Cov I	Covalent
M.P. (K)	1081	987	sub@453	203	180; S435	172
B.P. (K)	1738	1691		330	349	238
+ H ₂ O =	Neutral	s. Acidic	Acidic	Acidic	Acidic	Acidic
Conduc.(l)	High	High	Very low	None	None	None



Summary of trends in chlorides

■ Physical States:

- Ionic: solids at STP
- Covalent: volatile liquids or gases, low M.P

■ Formula:

Formula	NaCl	MgCl ₂	AlCl ₃	SiCl ₄	PCl ₅
El : Cl	1	2	3	4	5

■ Acid Base Character:

- Ionic (neutral) → Covalent (acidic)

■ Conductivity

- Ionic's: conductive when molten (liquid)
- Covalent's: non-conductive, although some products of reactions in H₂O produce ions

